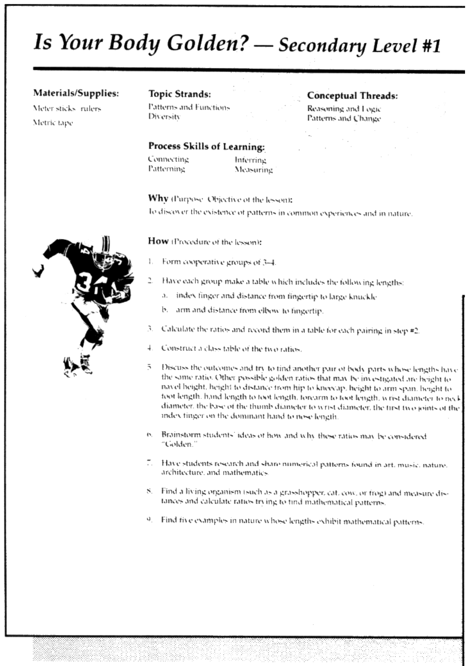
Is Your Body Golden?

"Is Your Body Golden?" is an example of one secondary–level instructional model that was developed by practicing teachers to reflect the philosophy of the Nebraska Mathematics/ Science Frameworks.

A reduced scale model is used on the inside pages to demonstrate how the Mathematics/Science Frameworks addresses the issues of multiculturalism, connections, inquiry/ problem solving, and assessment by showcasing one instructional model.

Frameworks In The Classroom



Is Your Body Golden? — Secondary Level #1

Materials/Supplies:
Meter sticks, rulers
Metric tape

Topic Strands:
Patterns and Functions
Diversity

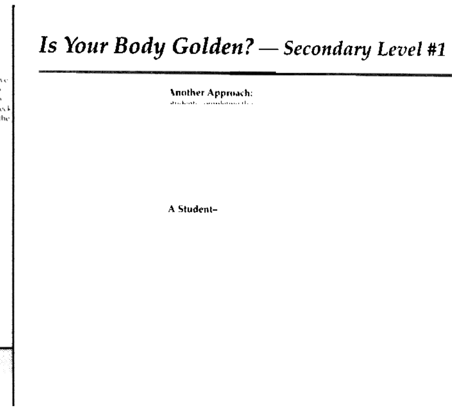
Conceptual Threads:
Reasoning and Logic
Patterns and Change

Process Skills of Learning:
Connecting
Patterning
Inferring
Measuring

Why (Purpose/Objective of the lesson):
To discover the existence of patterns in common experiences and in nature.

How (Procedure of the lesson):

1. Form cooperative groups of 3–4.
2. Have each group make a table which includes the following lengths:
   a. index finger and distance from fingertip to large knuckle
   b. arm and distance from elbow to fingertip.
3. Calculate the ratios and record them in a table for each pairing in step #2.
4. Construct a class table of the two ratios.
5. Discuss the outcomes and try to find another pair of body parts whose lengths have the same ratio. Other possible golden ratios that may be investigated are height to navel height, height to distance from hip to kneecap, height to arm span, height to foot length, hand length to foot length, forearm to foot length, wrist diameter to neck diameter, the base of the thumb diameter to wrist diameter, the first two joints of the index finger on the dominant hand to nose length.
6. Brainstorm students' ideas of how and why these ratios may be considered "Golden."
7. Have students research and share numerical patterns found in art, music, nature, architecture, and mathematics.
8. Find a living organism (such as a grasshopper, cat, cow, or frog) and measure distances and calculate ratios trying to find mathematical patterns.
9. Find five examples in nature whose lengths exhibit mathematical patterns.



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Another Approach:

A Student–

Connections:

- ♦ Existence of the Golden Ratio in ancient civilizations is discussed.
- ♦ Musical chords are explored to discover if there is a Golden Ratio.
- ♦ Ratios are computed and Fibonacci series and Golden Ratio are investigated.
- ♦ Possible patterns in nature, e.g., ratios of bones; arrangement of leaves on stem and relationship to one another; creation and development of certain structures such as pine cones and pineapples are investigated.
- ♦ The Golden Ratio in various artwork is examined.
- ♦ Architectural forms such as parthenon are examined to determine if they exhibit the Golden Ratio.

Inquiry/Proble

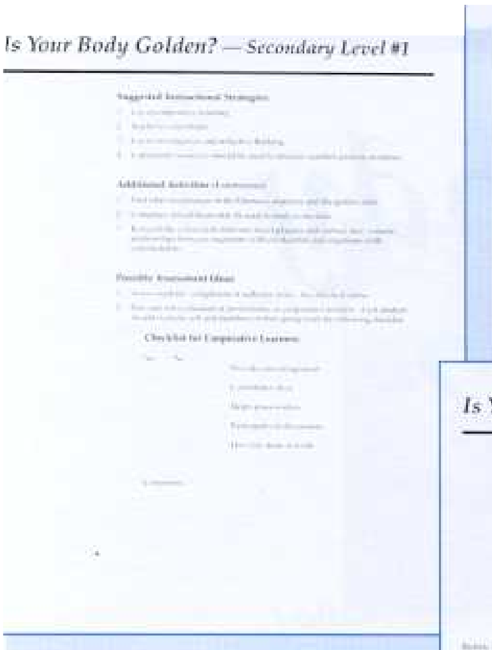
- ♦ Student exploration c
basis for concept dev
- ♦ Authentic tasks provic
investigate and solve

Multiculturalism:

- Data collection and analysis promotes exploration of human similarities and differences.
- Cooperative groups encourage positive student interaction
- Provides opportunities to research contributions of Greek Architecture (Parthenon) and sculptors (Polyleitos of Argos).

Assessment:

- Successful discovery of similar ratios is assessed.
- Authentic task with assessment rubric is included.
- Self evaluation of performance as cooperative learners is assessed by use of a checklist.



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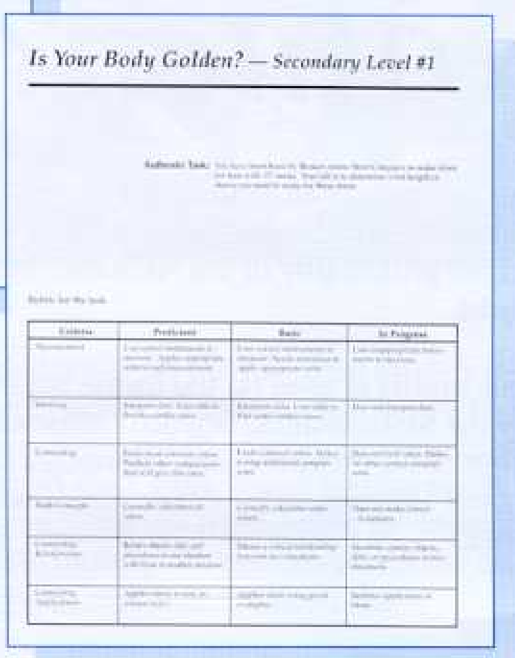

Is Your Body Golden? — *Secondary Level #1*

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elopment.

e real-life problems to

Students participating in "Is Your Body Golden?"

Three secondary–level instructional models developed from student–centered activities follow. Teachers who have piloted the models have reported pleasantly increased interest and engagement from their students, as well as much higher levels of student questioning. In workshops, the instructional models tend to generate healthy discussions about the implications of national standards and state frameworks.

Is Your Body Golden? Secondary Level #1

Materials/Supplies:
Meter sticks/rulers
Metric tape

Topic Strands:
Patterns and Functions
Diversity

Conceptual Threads:
Reasoning and Logic
Patterns and Change

Process Skills of Learning:
Connecting Inferring Measuring Patterning

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9. Find five examples in nature whose lengths exhibit mathematical patterns.

Another Approach:
Students completing the structured activity described in #1–9 will limit their explorations to the questions asked by the teacher. They will probably not generate their own questions and class members will all produce similar results. The students will focus on completing the activity. To reduce these limitations and allow students to explore, discover, and develop their own method to solve a problem, a more open-ended approach may be used. Using an inquiry/problem-solving

Is Your Body Golden? *Secondary Level #1*

strategy will produce a wide range of products as students define their problems differently and use different strategies to reach their conclusions. This method challenges the students to reach their potential using skills which have been developed in other activities.

A Student-Centered Approach:
1. Give students a bone such as a femur and estimate the size of the animal it came from.
2. Examine anatomical models to determine if they are properly proportioned.
3. Dissect owl pellets. Use number patterns to investigate homologous structures.
4. Investigate the surface area/volume relationship between organisms with exoskeletons compared to organisms with endoskeletons.

For Your Information (Background information for the lesson):
1. There is a *Math Vantage* videotape, available through the ESU or Nebraska Department of Education, on the Fibonacci sequence and the golden ratio.
2. Teacher may need to review computation of ratios before using this activity.
3. Consult math books and/or encyclopedias for background knowledge. The ancient Greeks considered the golden ratio the most pleasing in architecture. The golden ratio exists in the architecture of the Parthenon. A German Psychologist connected the golden ratio to the human body. Body part ratios will vary between children and adults
4. This activity is adapted from the Special Project "The Golden Ratio" on pages 475-480 in *Discovering Geometry* by Michael Serra, Key Curriculum Press.
5. *Donald in Mathemagicland* is a good video for providing examples of the Golden Ratio in a cartoon format.
6. Number patterns may be found in playing cards, credit cards, nature (the arrangement of leaves on a stem and their relationship to one another, the growth and development patterns of certain structures such as pine cones, pineapples, flower petals, the pattern of growth of the chambered nautilus, snails, sand dollars, and starfish), music, architecture, and art. More information may be found in *Favorite labs from Outstanding Teachers Vol. 2* (National Association of Biology Teachers (NABT), in the activity called "Fibonacci Numbers and Biological Patterns."
8. Recommended reference: *Fascinating Fibonacci - Mystery and Magic in Numbers*, Dale Seymour Publications, 1987, by T.H. Garland.

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Suggested Instructional Strategies:
1. Use of cooperative learning.
2. Teacher is a facilitator.
3. Use of investigation and reflective thinking
4. Community resources should be used to discover number patterns in nature.

Additional Activities (Extensions):
1. Find other occurrences of the Fibonacci sequence and the golden ratio.
2. Computer spreadsheets may be used to analyze the data.
3. Research the connections between insect plagues and surface area/volume relationships between organisms with exoskeleton and organisms with endoskeletons.

Possible Assessment Ideas:
1. Assess students' completion of authentic tasks. See attached rubric.
2. Peer and self evaluation of performance as cooperative learners. Each student should evaluate self and members of their group with the following checklist:

Checklist for Cooperative Learners:

Yes	No	
		Provides encouragement
		Contributes ideas
		Helps process ideas
		Participates in discussions
		Does fair share of work

Comments :

Is Your Body Golden? Secondary Level #1

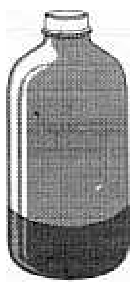
Authentic Task: You have been hired by Broken Arrow Shirt Company to make shirts for men with 15" necks. Your job is to determine what length of sleeve you need to make for these shirts.

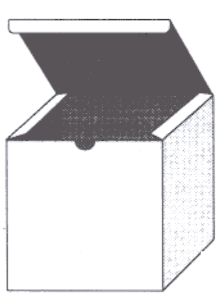
Rubric for the task

Criteria	Proficient	Basic	In Progress
Measurement	Uses correct instruments to measure. Applies appropriate units to each measurement.	Uses correct instruments to measure. Needs assistance to apply appropriate units.	Uses inappropriate instruments to measure.
Inferring	Interprets data. Uses table to find five similar ratios.	Interprets data. Uses table to find some similar ratios.	Does not interpret data.
Connecting	Finds most common ratios. Predicts other comparisons that will give this ratio.	Finds common ratios. Makes wrong additional comparisons.	Does not find ratios. Makes no other correct comparisons.
Math Concepts	Correctly calculates all ratios.	Correctly calculates some ratios.	Does not make correct calculations.
Connecting: Relationships	Relates objects, data, and procedures in one situation with those in another situation.	Misses a critical relationship between two situations.	Identifies similar objects, data, or procedures in two situations.
Connecting: Applications	Applies ideas in new or unique ways.	Applies ideas using given examples.	Restates application of ideas.

Can Can *Secondary Level #2*

Materials/Supplies:
Variety of containers
Rulers
Scissors
Graduated cylinders
Rice, corn, or beans





Topic Strands:
Spatial Relationships
Spatial Relationships
Interdependence

Conceptual Threads:
Problem Solving
Estimation
Systems and Interaction

Process Skills of Learning:
Communicating Connecting Problem Solving Reasoning

Why (Purpose/Objective of the lesson):
To apply area and volume concepts in an investigation to determine the most efficient/cost-effective use of materials in designing a closed container.

How (Procedure of the lesson):
1. Set up variety of containers. Students predict how much each container will hold.
2. Teacher records student opinions about most efficient and/or cost effective container.
3. Students select and measure three containers of their choice. Apply formulas and compare with actual capacity of container.
4. Teacher can provide or students may generate a checklist of expectations to be used for assessment purposes (see sample below).

   Checklist for Evaluation (refer to rubric for criteria)
   a. Develop definitions for "most efficient"/"cost-effective"containers.
   b. Formulate appropriate questions and predict answers.
   c. Make correct measurements in appropriate units to support conclusions.
   d. Construct a container with the correct capacity.
   e. Explain solutions in writing or orally.
   f. Present solutions to the class.
   g. Use appropriate volume and surface-area formulas.
   h. Compute ratios of surface areas to volume.
   i. Suggest other applications or extensions of the concept.

5. Teacher provides 250 ml of a substance (rice, beans, or corn). Students design a container to hold that amount of material with greatest efficiency or cost effectiveness.
6. Students construct a container from materials provided by the teacher.
7. Compile data from containers constructed in step five.
8. Share outcomes and strategies with other groups. Discuss surface areas and measure for each container.

Can Can *Secondary Level #2*

9. Try to reach consensus on the most efficient/cost-effective design.
10. In cooperative groups, research and select an environment and design a human container (dwelling) which is most efficient for that environment. Make a scale drawing and a written or oral report of each group's design.

For Your Information (Background information for the lesson):
1. Review units of measurement for area and volume.
2. Knowledge of area and volume formulas for solids would be helpful.

Solid Type	Volume	Surface Area
prism	area of base times height	sum of area of faces
cylinder	area of base times height	$2\pi r^2+2\pi rh$
pyramid	area of base times height/3	sum of area of faces
cone	area of base times height/3	πr (slant height) + πr^2
sphere	$[4\pi r^3]/3$	$4\pi r^2$

3 Students should be provided a list of the cost of materials if they are to calculate cost effectiveness.
4. Possible anticipatory sets:
   a. Make a foil mold of an ear of corn. Estimate how much of the mold will be filled by the shelled corn. Shell the corn and return to the mold. The corn without the cob should fill the mold.
   b. Using a balance scale, balance one large potato with several smaller ones. Time students as one person peels the larger potato and another peels the smaller ones, keeping the piles of peelings separate. Find the mass of each pile of peelings. Compare the separate times and masses. Examine the relationship between surface area and volume.
5. Explorations of human dwellings may include igloos, tepees, sod houses, solar homes, yurts, subterranean homes, dugouts, adobe houses, cliff dwellings, berms, or lodges.
6. Consult the English department for oral/written assessment.

Suggested Instructional Strategies:
Group discussions, cooperative groups of two or three, modeling.

Additional Activities (Extensions):
1. Research consumer preferences and marketing techniques as they pertain to product design.

Can Can *Secondary Level #2*

2. Students can determine whether a manufacturer has made the most economical packaging for their product.
3. Explore relationships of surface area to phenomena; i.e., wood splinters ignite easily while wood chucks do not; Alka-Seltzer tablets react with water more quickly when crushed; the relationship between cellular surface and volume.
4. Communicate findings to packaging companies.
5. Explore or research animal adaptations related to metabolism - surface area and volume in terms of retention and dispersion of heat. Stephen J. Gould has an interesting essay about this.
6. Make scale models of the dwelling designs.
7. Look at the energy efficiency of the dwellings.
8. Relate how the construction materials of their home connect to their physiological needs.
9. Invite a community member to discuss construction or engineering as a career.
10. Read and discuss *Loghouses in the Northwest USA*.

Possible Assessment Ideas:

1. Evaluate usability of container/dwelling. Share findings and supporting evidence with classmates.
2. See attached rubric for efficient container.

Authentic Task: You are a package designer for the Whole Earth Wild Rice Company. Your task is to design the most efficient, cost-effective package which maintains the quality of the rice and will hold a specified volume of rice. A written and oral presentation of your success and results needs to be given to the production managers. The managers will also want a model of the final package and demonstrated proof that the given volume will fit in the package.

Can Can Secondary Level #2

Rubric for Checklist (making an efficient container):

Processes/ Criteria	Proficient	Basic	In Progress
Questioning, Inferring, Interpreting, Reasoning	A number of quality questions developed involving the effect of one variable on another. Prediction of answers given and justified. Conclusion justified by referring to all work. Gives ecological impact of material used in package.	Questions not stated. Prediction not completely justified. Complete conclusion given but not justified. Ecological impact analysis unclear. Sources not given.	No questions, no prediction, incomplete conclusion, and ecological impact not given. Sources not given.
Measuring	Measurements are correct and are used to validate calculations or solutions.	Some measurements are incorrect or solutions are not validated using measurements.	Measurements are made but not used; most measurements are incorrect.
Modeling	Neatly constructed container, able to hold specified volume; demonstrates **efficient** packaging.	Constructed to hold most of specific volume. Some efficiency in packing evident.	Poorly constructed container, does not pack well, too small or too large for designated volume.
Communicating	Uses all symbols and terms correctly. Steps of methods explained in detail. Organized.	Uses symbols and terms with some errors. Gaps in explanation of method. Some organization is evident.	Uses symbols with some errors but no terms. Does not explain methods. Unorganized.
Inferring: Relevance of mathematics used	Demonstrates application of use of volume formula, uses surface area formula, and makes a ratio of surface area to volume.	Demonstrates application of use of volume formula and surface area formula but does not make a ratio of surface area to volume.	Demonstrates lack of application skills of using volume formula and surface area formula and ratio of surface area to volume.
Inferring: Recognition of the relevance of findings	Communicates a new extension of the problem.	Communicates a relationship to "previous experience."	Lack of ability to communicate relationship to other problems.

The Race is On *Secondary Level #3*

Materials/Supplies:
Electric fan with variable speeds
8 1/2 x 11 paper
Drinking straws
Wooden beads
¼" pins
Staples
Tape
Timing device such as ticker tape, photo gate, or video
Camera with motion detector
CBL (calculator based lab)

Topic Strands:
Force & Motion
Force & Motion
Algebraic Topics
Advanced Topics (Calculus)

Conceptual Threads:
Energy
Patterns of Change
Connections
Problem Solving

Process Skills of Learning:
Interpreting Data Modeling Problem Solving

Why (Purpose/Objective of the lesson):
To design wind-powered vehicles and compare the effects of different variables of design on velocity.

How (Procedure of the lesson):
1. Students should maintain a progressive journal throughout this activity. See attached checklist.
2. View selected scenes from the video "Wind" to introduce the topic of wind-powered vehicle design.
3. Students generate examples of resistance and friction. Have students gather information on aerodynamics and use of wind. Brainstorm effective characteristics of sail designs.
4. Pairs of students will design a vehicle from the given materials.
5. Construct a wind-powered vehicle using 1 piece of 8.5" by 11" paper, 8 straws, 4 beads, and 20 straight pins. All material must be used on the vehicle.
6. Vehicle will be powered by a fan.
7. Determine the velocity of the vehicle by using a ticker tape timer, photo gate, or video camera.
8. Conduct three trials. Determine the trial with the highest velocity.
9. Redesign the vehicle (student may incorporate other designs).
10. Retest the vehicle.
11. Simulate a race to determine the fastest vehicle. Then line up the vehicles in order to analyze the variables affecting velocity.
12. Record distance and time. Make a cumulative-distance/cumulative-time graph. Use graph to find:
    a. the average velocity (slope between 2 points), and
    b. the instantaneous velocity (slope of the tangent line at a chosen point).

For Your Information (Background information for the lesson):
1. Beads must spin smoothly around straws used for axles.
2. The first derivative of the position function is the formula for the instantaneous velocity.

The Race is On *Secondary Level #3*

Suggested Instructional Strategies:
1. Two persons cooperatively design a wind-powered vehicle.
2. Modeling and simulation are exemplified in this activity.

Additional Activities (Extensions):
1. Design an alternative powered vehicle such as solar, mechanical, or chemical.
2. Research momentum and potential and kinetic energy.
3. Construct a ramp to investigate variables such as the slope and length of the ramp.
4. Students may relate their research results to automobile design by obtaining information from local dealers and presenting to class.
5. Investigate fluid flow around regular geometric shapes.

Possible Assessment Ideas:
A progressive journal will be used to assess student performance. See checklist.

Checklist for Progressive Journal
1. The record should be written, oral, or audio/visual.
2. The task should be defined.
3. All handouts are included in the journal.
4. The journal is organized by date.
5. The journal contains a sketch of all the designs.
6. All changes in design are reported (may be pictorial, written, or oral). Include what was changed and why it was changed.
7. Report information and explain how this influenced the design.
8. All data are recorded.
9. Analysis of data contains data, graph, average and instantaneous velocity, and conclusion.
10. How did each of the team members function each day (self- and peer-assessment)?
11. Class discussions are summarized.